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The USAF Manufacturing Technology

PROGRAM STATUS REPORT

Air Force Research Laboratory / Materials & Manufacturing Directorate /
Manufacturing Technology Division / Wright-Patterson AFB, Ohio
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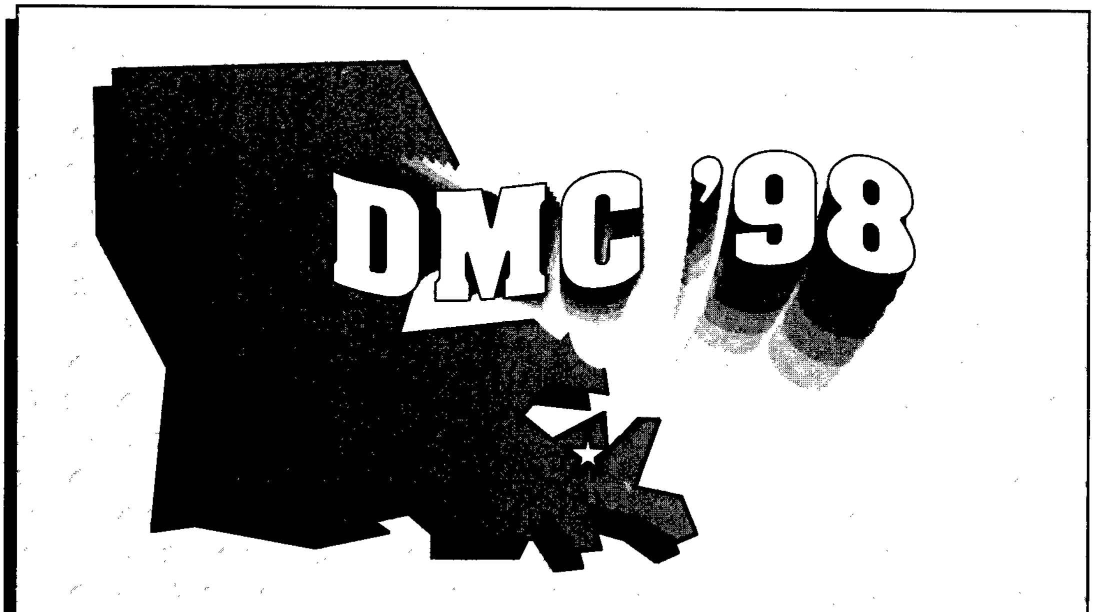

In this issue: ManTech's Top Efforts of 1998

Air Force Research Laboratory | AFRL

Science and Technology for Tomorrow's Aerospace Force

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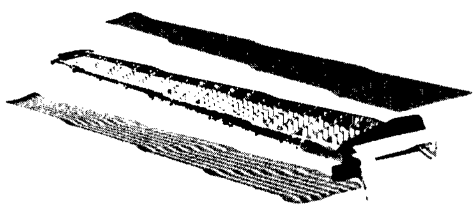
Military Products Using Best Commercial/ Military Practices saves money, reduces weight

Incorporating the best commercial practices into defense production facilities and expanding the potential for dual-use factories ultimately means more affordable weapon systems. This pilot program successfully demonstrated the ability to build a more affordable, lighter weight C-17 horizontal stabilizer in an integrated factory using best commercial/military practices, and to achieve equal or better quality levels, reduced weight, and a decrease in cost when compared to the existing business and performance baseline.

The pilot contract was structured in two consecutive phases. The Development Phase, Phase I, focused on selecting and prototyping the best business policies and practices, manufacturing infrastructure, and process technology improvements to be demonstrated in Phase II. The Demonstration/Validation Phase, Phase II, of the pilot effort finalized the design, fabricated a full-scale improved C-17 stabilizer using some of the selected business policies and practices, manufacturing infrastructure and process technology improvements from Phase I.



C-17 horizontal stabilizer torque box

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Contract Number:
F33615-93-C-4334

For more information, circle Reader Response Number 1

The program demonstrated a cost savings and a weight savings resulting from reduced contractor overhead (personnel and reporting), and the use of commercial practices in quality, financial and contracting approaches when compared to the pilot baseline. The pilot also provided sufficient data to support permanent changes to business policies and practices (FAR, DFAR, Mil SPECs, etc.) that eliminate entry barriers and enhance Department of Defense's ability to contract with firms employing "best practices" within the industrial base. In addition, the C-17 horizontal stabilizer torque box will be incorporated onto the C-17 Globemaster ship number 51 in late 1998.

This program has been co-funded by the C-17 System Program Office (SPO). Data collected throughout the program is being used by the C-17 SPO to determine if cost benefits are sufficient to warrant incorporation of revised business practices and manufacturing infrastructure improvements into the overall program. Transition of business policies and practices, manufacturing infrastructure, and process technology improvements to the C-17 SPO and the aerospace community will be a key measure of the pilot program's success.

ManTech Project Book Update now available

The latest issue of the book which describes the projects of the Manufacturing Technology Division is now in print. The **1999 Manufacturing Technology Project Book Update** was recently published and should be on its way to people who are on the mailing list for the Program Status Report. It will also be available soon on the Manufacturing Technology homepage at: **http://www.afrl.af.mil**

Anyone not on the mailing list or who cannot access this homepage should contact the division's Technology Information Center, at (937) 256-0194, to obtain a copy.

Interferometric Fiber Optic Gyroscopes Program improves guidance and navigation systems

Scientists and engineers at the Air Force Research Laboratory's Materials and Manufacturing Directorate have dramatically improved the manufacturing processes used to build Interferometric Fiber Optic Gyroscopes (IFOG) for tactical missile guidance and aircraft navigation systems.

The Manufacturing Technology for Tactical Grade Interferometric Fiber Optic Gyroscopes program used a teaming approach and variability reduction techniques including design of experiments, process and cost models, statistical process control and process capability measurements as well as automation to reach established program goals.

Missile guidance systems and aircraft navigation systems require highly accurate gyro subsystems in order to ensure targeting accuracy and flight safety. IFOG subsystems offer improved reliability, considerably lower cost and design flexibility over current mechanical and ring laser gyro subsystems. Prior to this program, IFOG component costs were high due to the fact that fabrication processes required extreme accuracy and assembly was labor intensive. Improved manufacturing processes were required to reduce IFOG production costs originally estimated at $6,000 to $7,000 per axis.

Under a contract sponsored by AFRL, Litton Corporation attempted to accelerate the integration of IFOG technologies into tactical missile guidance and aircraft navigation systems. Because much of the IFOG production cost is driven by component suppliers, a teaming approach was required. The Litton team included: EG&G (superluminescent diodes); Photonic Packaging Technologies (laser diodes); Marlow Industries (thermoelectric coolers); 3M Company (optical fibers); Pacific Precision Laboratories (fiber alignment stages); Ipitek (couplers); Ramar Corporation (integrated optic chips); Newport Corporation (power meters); Hewlett Packard and Optelecom (fiber optic gyro coil winders). Litton Corporation is developing bulk fiber winders used to perform the transfer winding of the optical fiber from the manufacturer's spools to quadrapole coilwinder transfer spools. Litton is also developing automated assembly stations for fiber preparation, splicing and rejacketing, and automated packing stations for integrated optics chip wire bonding, pull testing, cover attachments and strain relief application.

At the start of the program, the teams baselined their assembly production operations. Customer input from the Industry Review Board (IRB) and from the Advanced Medium Range Air-to-Air Missile (AMRAAM) JSPO was used to fill out quality function deployment matrices. These were used to focus the team's efforts. Process macro and micro flows were then used to provide metrics and traceability for the program. In addition, the team used variability reduction techniques including design of experiments, process and cost models, statistical process control and process capability measurements together with automation to obtain program goals. Their results were verified with two builds. The first gyro build took place in July 1996, and all the gyros built exceeded the program goals (30 gyros were built; half operated at 1.3 microns and half operated at 1.5 microns). The second build was completed during November 1997. The long-term objective is to establish the manufacturing processes and supplier base needed to reduce the cost of tactical grade IFOG subsystems by an additional 50 percent.

IFOG technologies offer improved reliability, significant cost reductions and design flexibility over mechanical and ring laser gyro subsystems currently in use. These efforts could result in a greater than 90 percent reduction in IFOG subsystem costs, better processes and more precise direction for the industry.

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For more information, circle Reader Response Number 2

DTIC QUALITY INSPECTED 3

MEREOS - product definition management system solves bills of materials problems

Almost all manufacturing enterprises producing complex products develop separate engineering, manufacturing, and logistical support, for their various engineering, manufacturing and maintenance activities. Each of these configurations inevitably differ from one another both in form and in content, and these differences mark the presence of certain kinds of relations that span bills of materials (BOMs).

The task of reconciling multiple BOMs for a product involves identifying components that stand in counterpart relations across them, and characterizing the properties of those relations. Establishing counterpart traceability is essential for managing engineering change and managing this process is possibly the most complex and costly activity in a manufacturing enterprise. Identifying and accommodating the ramifications of even a single modification to one component in one product BOM often requires the coordinated expertise of several specialty disciplines, such as materials and process, mechanical, electrical, and software engineering.

The multiple BOM phenomenon exacerbates this already difficult problem, since the impacts of changes to a component in one BOM must be determined for all of its counterparts in any other BOMs. Thus, there is a direct link between the multiple BOM reconciliation problem and the high costs and long lead times associated with engineering change.

These and related problems have received a great deal of attention; but until now, none have explicitly addressed the reconciliation problem. This project was intended to develop and demonstrate, in one or more production environments, a product definition management system which would solve the multiple bill of materials reconciliation problem in large-scale, complex product manufacturing environments.

The approach for solving the multiple bill of materials reconciliation problem involved the development of a product definition management system specifically designed to automate counterpart traceability across distinct BOMs for a given product. This system is designated MEREOS and was implemented as an application hosted by PACIS®, a database management system based on the ANSI/ISO 3-schema architecture. Three broad capabilities were supported with MEREOS: product structure definition and management; process structure definition and management; and technical document creation and integration. Each of these capabilities was delivered as an integrated suite of functions within a single application system running on UNIX® workstations and employing extensive interactive graphical interfaces.

MEREOS can be used in a number of different ways. A systems engineering organization can use it to support automated requirements analysis, decomposition, and traceability. A program management office or product group can use it as the core of a status accounting system. Manufacturing or logistics engineering groups can use the system as an application for defining "as-planned" or "as-supported" structures whose elements must be traceable to "as-designed" components and functional requirements. An information systems organization can use the system as a tool for update dissemination and database integrity maintenance in environments that have different systems managing different versions of product structures.

The MEREOS project provided end users with the ability to define, modify, query, and automatically maintain relationships between several distinct BOMs, specification trees, and functional structures for a single product, where the information involved is stored in geographically distributed heterogeneous databases.

For more information, circle Reader Response Number 3

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Metal Forming Simulation project improves forming process

The Metal Forming Simulation program established a three-dimensional (3-D) computer-aided design/computer-aided manufacturing/computer-aided engineering (CAD/CAM/CAE) system to simulate the fluid cell sheet metal forming process.

The system predicts anticipated forming defects and provides a solution to eliminate the defect during the design or manufacturing. It also provides critical parameters for tool design.

Rubber pad forming (fluid cell process) is one of the important methods of forming aluminum sheet parts to repair airframes at Warner-Robins Air Logistics Center (WR-ALC). Prior to this effort, WR-ALC had difficulty in fabricating aluminum sheet parts resulting in dimensional inaccuracies and defects. They produced a high quality part, but the cycle time was too long and the cost was too high. The forming dies were designed by trial-and-error and the experience-based die design practice was costly and often required long-lead times.

The objective of this project was to improve product quality, reliability, and reproducibility while simultaneously reducing turn-around time and cost of fabricating sheet metal aircraft parts. The effort established a 3-D CAD/CAM/CAE system which predicts anticipated forming defects such as tearing and wrinkling and provides a solution to eliminate the defect during the design or manufacturing.

The system models the cold forming of aluminum and steel sheet metal components for the F-15, C-130 and C-141 aircraft at WR-ALC, in particular, and is capable of modeling sheet metal components 10 times larger, as those found on the C-5 aircraft. The system develops a 3D CAD model from the actual part, develops a blank shape of the part, calculates the tool parameters, evaluates the producibility, and modifies/optimizes the manufacturing process. The system provides intuitive user interface, accurate results, fast execution, extensive material database, automatic meshing, unique contact algorithms, prediction of springback, crack and wrinkling, prediction of forming pressure, and suggestion for alternative design/process in case of failure.

Based on military parts that have been formed at Northrop Grumman Corporation using this system, handwork has been reduced by 90 percent, rejection rate has been reduced by 95 percent, the capability index number (CpK) has been approached to 1.3, and the cycle time has been reduced by 78 percent. The Air Force expects to realize the same magnitude of benefits when the system is installed at WR-ALC.

Besides the military applications, the technology developed in this system may be transferable to other commercial applications in areas such as automotive, appliance, consumer, and medical. A representative from the Chrysler Research & Development department has contacted the ManTech project engineer regarding potential application in the automobile production. These discussions will be further pursued with Northrop-Grumman.

Benefits include elimination of scrap, substantially reduced throughput time, reduced part variability, elimination of trial-and-error in tool and part fabrication, and a potential first year cost savings of $1 million when fully implemented to replace current operations.

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Contract Number:
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For more information, circle Reader Response Number 4

Mobile Automated Scanner project improves nondestructive inspection capability

As the Air Force fleet ages, a concerted effort is required to prevent the deterioration of important parts and surfaces. Corrosion, stress and fatigue attack metallic components, while disbonds and delaminations can cause failure in composite parts. Tightening budgets demand increased effectiveness in locating, stopping and preventing these problems, which most commonly occur in inaccessible locations.

The Mobile Automated Scanner (MAUS) IV project built on the success of the MAUS III system and improved the manufacturers' and maintenance technicians' ability to perform accurate, nondestructive inspections and evaluations of large composite and metal components in less time and with more ease and efficiency.

The MAUS system uses several ultrasound and eddy current methodologies to locate structural material problems in composite laminates, co-cured complex composites, bonded assemblies and metallic structures used in Air Force weapon systems. Pioneering work in MAUS technology led to the successful design and development of a portable scanning system (MAUS III), a hand held detection system that is suitable for depot or field inspection work. Building on the successful capabilities of MAUS III, scientists and engineers created MAUS IV, replacing existing workstation computer hardware with a more user-friendly personal computer system.

MAUS IV computer software enhancements also include extensive data interpretation tools, a programmable system set up and archival data storage capability, and enhanced data imaging.

The MAUS IV scanner being used on a KC-135.

MAUS IV incorporates a specially designed 43-inch long, computer-controlled flexible track designed to facilitate inspection and evaluation of large sections of the aircraft, most smaller sections, and many of the curved and contoured areas, without the hand held scanner.

MAUS IV has expanded research in pitch-catch resonance, mechanical impedance analysis and eddysonic and automated tap testing, which has resulted in several improvements to the sensors used to detect structural component material problems. These combined research and development efforts, which ultimately led to the creation of the MAUS IV, were initiated under the "Large Area Composite Inspection System" (LACIS) and were later continued under the "Large Area Inspection of Disbonds" (LARID) program. Continued test and evaluation of MAUS IV technologies could spur expanded application throughout the Air Force, the Department of Defense and in the private sector.

For more information, circle Reader Response Number 5

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F33615-91-C-5664

Military Products from Commercial Lines project reduces costs of military electronic components

The shrinking defense industrial base and weapon systems affordability are critical issues facing all DoD programs. This pilot attacked the issues of dual-use and affordability by producing military components on a commercial line at lower cost and comparable quality to those produced on a dedicated military line.

Military Products from Commercial Lines (MPCL) program demonstrated that military modules can be redesigned for commercial manufacture using commercially available components, thus reducing acquisition costs by more than 50 percent.

Digital electronic modules compatible with the F-22 Advanced Tactical Fighter and the RAH-66 Comanche Helicopter were processed on a commercial automotive manufacturing line.

The demonstration included processing small volume, complex military modules among larger volumes of commercial products using computer integrated manufacturing and existing commercial production processes and equipment. The program also considered business practices by demonstrating how requirements can be defined without relying on military specifications and standards and providing a model subcontract for commercial suppliers.

Data has shown that commercial components meet military requirements in reliability and durability for these applications. The demonstration modules are the same form, fit, and function as their more expensive military counterparts. Further benefits in weight reduction occur due to the use of plastic component packaging in lieu of ceramic packages required by military specifications.

By using commercial suppliers, the defense industrial base is expanded, and more high quality, high efficiency manufacturers are available, especially in electronics. It has been the intent of MPCL to show that the DoD can benefit by leveraging commercial manufacturers and to capture and transfer the process of doing so. Although significant cultural resistance still exists, the mechanisms for building military products on commercial lines are beginning to fall into place.

Incorporation of commercially produced military avionics on military aircraft will dramatically reduce the cost of electronic suites by taking advantage of economies of scale and automated manufacturing processes. Several other aircraft have been identified as potential beneficiaries of this program.

The MPCL program has broken down many barriers to building military products on commercial lines, has demonstrated key concepts of acquisition reform, and has provided much needed data in related business practices, manufacturing infrastructure, and process technology. Through its success, the program has received wide visibility, and was briefed to former Secretary of Defense, William Perry.

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For more information, circle Reader Response Number 6

Manufacturing technology improvements reduce costs of multi-band gap solar cell array

The cost of a launch vehicle can be as much or more than the satellite it is putting into space. Reducing the launch vehicle's size can cut overall costs by 200 to 300 percent. Even if the launch vehicle size cannot be reduced, a lighter satellite equates to larger amounts of station-keeping propellant loaded aboard, which means a longer service life for the satellite.

The objective of the Manufacturing Technology for Multi-Bandgap Solar Cells project is to produce monolithic III-V multi-junction solar cells grown on silicon or germanium substrates for space applications. The goal is to escalate yield, increase efficiency, and reduce cost by improving the manufacturing processes of these cells. If the program power efficiency and cost goals are achieved, a 14 percent cost savings per watt can be expected.

This effort will build upon the work done by Phillips Laboratory in developing multi-junction technology, and upon the Manufacturing Technology Division's single junction gallium arsenide (GaAs) solar cell program and the gallium arsenide-on-germanium solar cell program. The program has three phases. Phase I will define a baseline to establish current capabilities. In Phase II, the contractor will refine the metal organic chemical vapor deposit growth process, among others, using design of experiments and other quality engineering techniques. In Phase III, the contractor will validate the process improvements with a final validation production run.

The benefit of this effort will be the establishment of manufacturing processes for affordable, power efficient, space-qualified multi-band gap solar cells.

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Contract Number:
F33615-95-C-5508

For more information, circle Reader Response Number 7

Ultra-thin cast nickel-base alloy structures used for lightweight turbine engine components

Many cast turbine engine components are manufactured thicker than structural design analysis require. Continued improvements in gas turbine technology requires development of lower weight structural components with higher metal temperature capability.

To help achieve this goal, the Ultra-Thin Cast Nickel-Base Alloy Structures program has developed a cost-effective manufacturing processes capable of producing ultra-thin (10-20 mm) single-crystal cast components.

Current state-of-the-art casting techniques are limited to 0.060-0.070 inches minimum thickness. However, the feasibility to cast small-scale ultra-thin structures in the range of 0.010-0.020 inches thick has been demonstrated. Working with engineers from the Air Force Research Laboratory, United Technologies Corporation developed this technology for the cost-effective fabrication of reproducible and reliable large geometrically complex components.

Ultra-thin cast nickel-base structural castings is a critical technology that will reduce engine weight, improve thrust-to-weight ratio, increase durability, and improve range. The component selected to demonstrate the process technology was the F119 transition duct liner. The current baseline F119 transition duct section is a multi-piece fabricated component consisting of 1,380 separate parts and 120 manufacturing operations. A cast one piece design will reduce this to 20 separate parts and 40 manufacturing operations.

A separate but parallel program is underway aimed at establishing a coating process for the liner. The liner portion of the program will be conducted in three phases with several subtasks per phase. In Phase I, a casting supplier and material will be selected and a sub-element configuration will be designed for casting process development trials. Rapid prototyping will be employed for the sub-element tooling and solidification modeling, and intelligent process control will be used throughout the technical effort. Sub-elements and mechanical property specimens will be evaluated to assess the casting process selected in Phase I. In Phase II, a larger size sub-component based on the Phase I results will be designed. The selected casting process shall be optimized and employed to cast sub-components for laboratory and engine testing on the Component and Engine Structural Assessment Research (CAESAR) engine. Following engine test on CAESAR, the sub-components will be evaluated and a cost analysis will be provided for producing a full-scale component relative to current Bill-of-Material configuration. A preliminary assessment of applicable repair methods for the cast sub-component will be identified based on engine test experience, and selected repair methods demonstrated.

This program is aimed at applying advanced materials processing technology to the manufacture of propulsion and structural components. Modifications can be made to existing Air Force and Navy weapon systems where light-weight components are required, so they can use this technology. This technology is capable of manufacturing 100 percent retrofitable components and is also applicable to castings on commercial engines.

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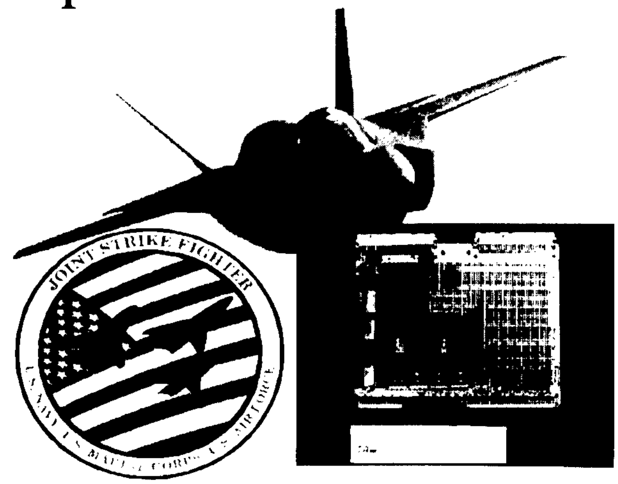
Contract Number:
F33615-93-C-4305

For more information, circle Reader Response Number 8

Continuous electronics enhancements developed using simulatable specifications



Joint Strike Fighter Pulse Interval Pre-processor (and logo)

Engineers at the Air Force Research Laboratory Materials and Manufacturing Directorate, working with Motorola, Mentor Graphics, TRW and the University of Cincinnati have developed a virtual prototyping process that substantially improves electronic subsystems manufacturing.

The new process, developed under the Materials and Manufacturing Continuous Electronics ENhancements using Simulatable Specifications (CEENSS) program, reduces ambiguities and conflicts in system specifications that can lead to costly design errors and manufacturing rework during product development cycles. The result is a first pass manufacturing article that enables the electronic subsystem to be developed "right the first time."

English language descriptions of current board/module-level development processes used to manufacture electronic subsystems often leave specification and design errors undetected until late in the development cycle. The main cause of these errors has been ambiguous, inconsistent and incomplete requirements, which often result in large integration and test efforts to identify and correct the problems resulting from the faulty requirements and manufacturing rework to obtain usable products. In addition, current early design processes focus on the incorporation of specific technologies and components that eventually become obsolete due to the overall lengthy system development process, resulting in costly retrofits downstream.

The CEENSS strategy for an improved process focuses on requirements and is designed to remove ambiguities which can lead to errors in understanding and in translating functional requirements to specific designs. Until recently, efforts to replace free-form developmental processes with more formal mathematical techniques have been only partially successful, foundering on attempts to address the complex problem of formal design verification. The CEENSS program successfully addressed this critical issue through the development of Simulatable Specifications (SIMSPECS). As a key technical component of CEENSS, SIMSPECS embodies all the requirements and verification procedures in a combination of traditional and formal expression. SIMSPECS addresses the problems of ambiguity and inconsistency and then provides the basis for controlling the propagation of requirements to all levels of design, withholding as long as possible the selection of specific technology /design implementation. Leveraging accepted technologies and processes by the electronic design community, CEENSS is embracing successful techniques in order to establish a

For more information, circle Reader Response Number 9

methodology and modeling guideline which would enhance virtual prototyping processes and be commensurate with accepted practices.

As part of the program's verification and validation plan, CEENSS has been employed in the design and development of two Air Force avionics packages. The first demonstration centered on the F-22's Pulse Interval Pre-processor (PIP), a critical component of the aircraft's Communication, Navigation and Identification (CNI) avionics suite. The second demonstration focused on an F-22 out-of-production parts issue resulting in obsolete electronic technologies for CNI. In the first case, the PIP was redesigned using the CEENSS process used for the Joint Strike Fighter (JSF) Integrated Sensor Subsystem (ISS) program (an advanced technology development program which investigates a new modular architecture for porting the F-22 CNI to a future JSF platform). Using the CEENSS approach, TRW virtually prototyped the PIP design in six months as opposed to the originally planned nine, a 33 percent design cycle time reduction. The most significant benefit, however, was achieved in the integration and test process of the overall development in which the PIP was integrated into the ISS program within two weeks rather than 12 weeks, as forecasted. These benefits were directly attributed to the employment of the SIMSPECS and overall CEENSS program.

The second demonstration used a more aggressive approach for verifying and validating CEENSS. The mini-board design was modified to provide for reconfigurable thresholds to accommodate mission requirements for other systems such as the JSF, with the result being reduced overall part counts, increased performance parameters, reduced weight and a more affordable product to support.

As a result of these demonstrations, the JSF System Program Office has endorsed CEENSS technologies and has instituted a requirement that they be included in the JSF Avionics Design Document. Their action marks a crucial step toward enabling a form, fit, function and interface program management strategy for future weapons systems. In a parallel demonstration, CEENSS technologies helped a leading producer of commercial communication products, Motorola, reuse the design of an existing family of pagers. The core functionality of the pager's design was modified with additional capabilities, successfully generating a new product design while significantly reducing the time to market.

The new process also enables on-time delivery, more affordable acquisition and sustainment processes, greater aircraft mission availability and a formalized virtual prototyping process and data package which enables rapid adaptability to changing requirements. The successful technology transfer of CEENSS technologies to the commercial sector has reduced design cycle times and time to market, and significantly enhanced product quality.

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Contract Number:
F33615-93-C-4304

End of Contract Forecast

DATE	PROJECT TITLE CONTRACT NO.	PRIME CONTRACTOR	POINT OF CONTACT
December 1998	Intelligent Processing of Materials for Chemical Vapor Infiltration F33615-96-C-5839	Technology Assessment & Transfer Incorporated Annapolis, MD	Claudia Kropas-Hughes (937) 255-8787
December 1998	Electric Component Commerce F33615-96-2-5116	Digital Market Sunnyvale, CA	William Russell (937) 255-7371
December 1998	Flat Panel Displays Contract No.: Multiple	Dpix Incorporated Palo Alto, CA	John Blevins (937) 255-3701
December 1998	Electronic Component Information Exchange F33615-97-2-5121	Silicon Integration Initiative Austin, TX	William Russell (937) 255-7371
December 1998	Self Orienting Fluidic Transport (SOFT) Assembly F33615-96-C-5111	Beckman Display Incorporated Berkley, CA	Charles Wagner (937) 255-2461
December 1998	Internal Real-Time Distributed Object Management System F33615-96-C-5112	Systran Corporation Dayton, OH	David Judson (937) 255-7371
December 1998	Mixed Signal Test (MiST) F33615-95-2-5562	Boeing Company Seattle, WA	William Russell (937) 255-7371
December 1998	Joint Strike Fighter (JSF) Technology Manufacturing Demonstrations F33615-95-C-5529	Hughes Company, Aircraft Division Los Angeles, CA	Alan Herner (937) 255-9245
December 1998	New England Supplier Institute (NESI) F33615-94-2-4424	Corporation for Business, Work, & Learning, Center for Applied Technology Boston, MA	Wallace Patterson (937) 255-4623
January 1999	Electronics CAD-CAM Exchange (ECCE) F33615-96-C-5118	Intermetrics Incorporated McLean, VA	William Russell (937) 255-7371
January 1999	Instrument for Rapid Quantitative & Nondestructive Wafer Evaluation F33615-96-C-5108	Sentec Corporation Walled Lake, MI	Walter Spaulding (937) 255-2416
January 1999	Continuous Electronics ENhancements Using Simulatable Specifications (CEENSS) F33615-93-C-4304	TRW Incorporated Beavercreek, OH	Theodore Finnessy (937) 255-4623
February 1999	Manufacturing Technology for Multi-Bandgap Solar Cells F33615-95-C-5561	Spectrolab Incorporated Sylmar, CA	P Michael Price (937) 255-2461
March 1999	Simulation-Based Design System for Multi-Stage Manufacturing Processes F33615-98-C-5161	Technirep Incorporated Eaton, OH	James Malas (937) 255-8786

DATE	PROJECT TITLE CONTRACT NO.	PRIME CONTRACTOR	POINT OF CONTACT
March 1999	Development of Affordable Optic Chips F33615-97-C-5124	Ramar Corporation Northborough, MA	Ronald Bing (937) 255-2461
March 1999	Missile Industry Supply Chain Technology Initiative (MISTI) F33615-96-C-5115	Science Applications International Corp McLean, VA	Jon Jeffries (937) 255-7371
March 1999	Multiphase Integrated Engineering Design (MIND) F33615-96-C-5621	University of Utah Salt Lake City, UT	Theodore Finnessy (937) 255-4623
March 1999	Supply Chain Integrated Product/Process Development (IPPD) Pilot Project (SCIP) F33615-96-2-5602	Automotive Industry Action Group Southfield, MI	George Orzel (937) 255-4623
April 1999	Simulation-Based Design System for Multi-Stage Manufacturing Process F33615-98-C-5163	Deformation Control Technology Incorporated Cleveland, OH	James Malas (937) 255-8786
April 1999	Metal Forming Simulation for Stretch-Forming Process F33615-98-C-5120	Northrop Grumman Corporation El Segundo, CA	Deborah Kennedy (937) 255-3612
April 1999	Identification & Quantification of Structural Damage (Structural Repair of Aging Aircraft) F33615-97-2-5151	Northrop Grumman Corporation El Segundo, CA	Michael Waddell (937) 255-7277
April 1999	Dynamic Polymer Composite (DPC) Connectors for Affordable Composite Structures F33615-97-C-5126	The Technology Partnership Grosse Isle, MI	Vincent Johnson (937) 255-7277
April 1999	Flexible Environment for Conceptual Design F33615-96-C-5617	Rockwell International Corporation Palo Alto, CA	Daniel Lewallen (937) 255-7371
April 1999	Built-In Test of Known Good Die F33615-96-1-5610	Rutgers State University Piscataway, NJ	William Russell (937) 255-7371

Reports

Agile Business Practices Demonstration Project
Alog Number: 4136
Contract Number: F33615-96-2-5602
Technical Report Number:
AFRL-ML-WP-TR-1998-4086
Distribution: LIMITED

Development of a New Precision Magnetic Spindle Technology
Alog Number: 4141
Contract Number: SPO900-94-C-0007
Technical Report Number: WL-TR-97-8056
Distribution: LIMITED

Design Information Retrival Using Geometric Content
Alog Number: 4142
Contract Number: F33615-96-C-5615
Technical Report Number:
ML-WP-TR-1998-4053
Distribution: LIMITED

Process Web: Process Enable Planning & Composition of an Agile Virtual Corporation
Alog Number: 4143
Contract Number: F33615-96-C-5604
Technical Report Number:
ML-WP-TR-1998-4087
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Electrostatic Printing of High Definition Microstructures for Flat Panel Displays
Alog Number: 4144
Contract Number: F33615-96-C-5104
Technical Report Number:
ML-WP-TR-1998-4030
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Videos

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The USAF Manufacturing Technology

PROGRAM STATUS REPORT

Winter 1998

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